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SATELLITE MONITORING EARTH RESOURCES MAY ALSO BE VALUABLE TOOL IN PREDICTING FLOODS

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SEPTEMBER 11, 1974

When Tropical Storm Agnes dealt its devastating blow to the Susquehanna River Basin and much of the East Coast of the United States, in June of 1972, the need for an improved communications network for flood forecasting became a stark reality.

As the flood waters rose to record levels, 22 of 60 river gaging stations on the Susquehanna River became inoperative or were destroyed and communications systems began deteriorating because of power failures and downed phone lines causing delays in the issuance of vital forecasts.

An improved communications network could serve as a backup to the regular system to insure that data from the field would be available to water resources managers and forecasters under extreme emergency conditions as existed during Agnes. In response to this need, the Susquehanna River Basin Commission (SRBC) entered into a cooperative agreement with the United States Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) to test experimental satellite communications equipment, which could provide stream gage and rainfall data for faster and more accurate flood predictions in the Basin.

The Commission was briefed in December of 1972 by the USGS about the possible use of NASA's Earth Resources Technology Satellite (ERTS) to experimentally monitor and relay back

to earth hydrologic data from field locations.

Launched by NASA in July of 1972, ERTS is a low-altitude, polar-orbiting satellite that is the first American experimental satellite designed solely for the gathering of earth-resources data. The USGS is testing the satellite quite extensively for relaying hydrologic and geologic field data.

The satellite has aboard three experimental systems that may be used. Two of these systems, the Multispectral Scanner (MSS) and the Return Beam Vidicon Camera (RBV) provide imagery of the earth's surface, while the satellite's Data Collection System (DCS) relays earth-resource data that have been transmitted by widely dispersed ground-based radios to a central computer facility.

The imagery systems (MSS) and (RBV) simultaneously collect reflected radiance of the earth's surface in four spectral bands of the electromagentic spectrum. The radiance from each band can be formatted into a black and white image. Each image portrays a scene of the earth's surface. Two or more images can be digitally or optically combined to identify and map a wide variety of environmental features of the earth's surface. The satellite's polar-orbit permits a least one opportunity every 18 days to image any location in the world between 81 degrees North, and

81 degrees South latitude.

The ERTS-DCS is a communications system that consists of small low-powered, battery-operated radio transmitters, which are called Data Collection Platforms (DCP's), a radio transponder aboard the ERTS satellite, and ground data reception sites. A DCP may be placed at any location where data collection is required. The satellite orbits the earth about 14 times daily, and can relay data whenever a DCP and a ground site are mutually visible from the satellite. This happens whenever the satellite is within about 1,600 miles of both a DCP and a ground site, which occurs during a brief period on each of several daily orbits. The satellite is at an altitude of 571 miles and can communicate almost to the horizon of the earth with a DCP, or a ground site. The DCP transmits a brief data message of 0.04 seconds duration once every 90 or 180 seconds, and communication with a ground site is established several times daily when mutual visibility with the satellite occurs. The number and duration of the mutual visibility periods is primarily a function of the geographical positions of the DCP and ground site, and visibility of the sky permitted by local terrain. Two NASA ground sites, at the Goddard Space Flight Center in Greenbelt, Maryland, and Goldstone, California, provide coverage for the continental United States, Canada, Mexico and most of Central America. The ground sites permit data from continental

American DCP's to be relayed during 3 to 7 orbits daily while mutual visibility periods of 12-14 minutes per orbit are available.

After consideration by the Commission of the program's potential for improving flood forecasting and warning, a decision was made to support the placement and testing of four monitoring platforms in the Basin.

Currently there are four DCP's in operation monitoring stream stage at Harrisburg, Pennsylvania on the Susquehanna River; at Lewisburg, Pennsylvania on the West Branch of the Susquehanna River; at Newport, Pennsylvania on the Juniata River; at Towanda, Pennsylvania on the Susquehanna River. DCP's located at Harrisburg and Newport, Pennsylvania have been equipped with add-on-memory units. These memory-unit equipped DCP's store and transmit the 12 most recent hourly river stages.

The satellite collects data from the DCP's during orbits between 8 a.m. and 12 noon and 8 p.m. and 1 a.m. This information is then recorded at the two ground sites in either Maryland or California, depending upon the location of the satellite, and transmitted to the NASA computer. The data are sent by teletype to the local USGS office for processing and evaluation. The total time elapsed from transmission of data from a DCP to receipt at local USGS

office is less than one hour. The Commission is currently receiving data by mail from the USGS office in Harrisburg. In an operational system the data could be made available quickly by teletype.

There are several advantages to the system the Commission believes are worth evaluation. The expense and complexity of conventional landline or microwave installations could be avoided. Such installations usually are vulnerable to damage during critical storm periods. Since the DCP's are easily installed, and are battery operated, the time-consuming and expensive cost of installing landline power to remote locations also could be avoided. Local USER ground-receive sites, which could be used to acquire data directly from the satellite are technically feasible and could be powered by emergency generators. They could be operated by regional agencies to insure continuous data collection during critical storm or disaster periods.

The imagery of ERTS can help achieve management goals, like those of the SRBC, assist in control of basin water resources and even assist in locating new sources of fresh water.

The Commission also plans to use the ERTS imagery data in a land-use mapping project in conjunction with its water quality program. The mapping would aid in identifi-

cation and evaluation of nonpoint source pollution problems.

The maps once completed also can be used for additional detail studies for recommending a program for nonpoint source pollution control and for other water resources management programs in the basin.

The USGS has tested about 100 DCP's nationwide with a variety of instruments such as stream gages, water-quality monitors, groundwater observation wells, precipitation and waterstage recorders, meteorological recorders, snow pillows, and geologic instruments such as microseismic recorders and tiltimeters. Data from these and other field monitors can provide needed information regarding rainfall, land usage for food production and a wide variety of other environmental conditions. ERTS imagery also monitors pollution along coastal areas of the oceans as well as inland seas and waterways. Large areas of the United States where extensive strip mining has occurred can be imaged rapidly and accurately to define areas of potential rehabilitation.

Although in the experimental stage, the first 24 months of operations have been quite successful. The satellite has orbited the earth more than 10,000 times and produced more than 70,000 images of the earth's surface, photographed virtually all of the United States land mass and provided useful photographs of more than three-fourths of the earth's surface.

Along with the SRBC there are about 300 investigators from governmental, academic and industrial activities in the U. S. and more than 35 other countries participating in the ERTS Program to help broaden man's knowledge in many scientific areas.

In May of this year the first of another satellite series was launched that may further broaden man's knowledge of the world around him. The satellite is known as the Geostationary Operational Environmental Satellite (GOES) and it also is capable of collecting and relaying field data. The purpose of the GOES-Data Collection System (DCS) is to permit the operational collection of environmental data from 10 to 20,000 remote collection sites via satellite telemetry to centrally located satellite receiving sites. There are three elements to the GOES-DCS. They are geostationary satellites, DCP's and ground receiving sites.

A "self-timed" DCP will transmit data at a preset time interval of 3-6 hours and cannot be interrogated by the satellite. Both types of GOES-DCP's have a definite advantage over ERTS-DCP's in that a larger quantity of hydrologic data can be transmitted at one time, thus allowing for collection of more frequently sensed readings.

Through ERTS, USGS can accumulate hourly readings for one parameter; whereas, through GOES, they hope to accumulate

15-minute readings from more than one parameter. One interrogatable GOES-DCP purchased by the Geological Survey will be installed at the Harrisburg, Pennsylvania gaging station. Five self-timed convertible DCP's (C/DCP), which can be modified to communicate with either ERTS or GOES, have been purchased by the USGS and will be installed at sites in the Susquehanna River Basin mutually agreed upon by the USGS, the Susquehanna River Basin Commission, and the National Weather Service, River Forecast Center.

One prototype C/DCP and one interrogatable DCP will be operational in the fall of 1974. The SRBC may support testing of four additional C/DCP's which will be available in the spring of 1975 to investigate the feasibility of placing many such stations within the basin.

Data relayed by GOES will be furnished to USGS in Harrisburg, Pennsylvania from NOAA's National Environmental Satellite Service in Suitland, Maryland via commercial teletype. Computer software will be developed by USGS in Harrisburg to screen and process the data and to disseminate data summaries to SRBC and other users.

By the end of 1975, there will be three geostationary satellites in orbit which will be operated by the National Environmental Satellite Service (NESS) a division of the National Oceanic and Atmospheric Administration (NOAA). A western satellite will be placed over the equator at 135 degrees W. longitude which will cover the United States,

Alaska, and Hawaii; an eastern satellite over 70 degrees W. longitude to cover the continental United States and Central and South America. A third satellite will be an in-orbit spare. A fourth and fifth satellite are programmed for future use.

The satellite launched this past May was maneuvered into a position 22,591 miles above Brazil, where its orbital speed will match the rate of the earth's rotation. This will keep the satellite over the same geographical area, enabling it to perform a greater variety of roles than previously undertaken in such missions.

Among the other roles planned for GOES during its work-days in space are watching the sun for eruptions that might endanger astronauts or travelers in supersonic transports, the relaying of premonitory signs of an earthquake or tidal wave, the passing along the mid-ocean observations and the transmissions of weather data and cloud cover images to remote ground stations.

Each satellite is capable of monitoring 10,000 data collection platforms on land, sea and suspended from balloons. By relaying command signals from the ground it can call each DCP "by name" - that is, by a preprogrammed signal-commanding it can make certain observations. Alternatively,

in an emergency - for example, when an automatic station detects signs of an impending earthquake, flash flood or tornado - it can break into the communications system, clearing the air waves for its report.

With miniaturization of electronic components and ever advancing computer technology many scientists feel it will become more economical and accurate to monitor Mother Nature and her environment with satellites than by any other means.

In the future the Commission will be keeping abreast of advances in environmental resources technology. This will enable it to better realize its responsibilities and goals for the efficient and economic management, development and use of water and related resources of the Susquehanna River Basin.